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Studies on Mollusk Populations
V. -- *Tegula rugosa* (A. Adams, 1853)

BY

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(4 Textfigures)

Arthur Adams described Chlorostoma rugosum at the meeting of the Zoological Society of London under the date of May 27, 1851 (actually published in 1853) as follows:

"C. testâ turbinatâ, profundè umbilicatâ, luteo-fuscá, nigro variegatâ, longitudinaliter nodoso-plicatâ, transversim sulcatâ; anfractu ultimo rotundato, infra suturam angustato; columellâ incurvatâ, anticè bituberculatâ, tuberculo supremo magno, prominente; labro fusco marginato.
Hab. —?"

This brief description may be translated, somewhat freely, as follows:

'The shell of this Chlorostoma is top shaped, deeply umbilicate, yellowish brown with black markings, longitudinally with nodose folds and transversely with grooves; last whorl rounded, narrowed at the suture; columella incurved with two tubercles anteriorly, the upper of which is large and prominent; lip with brown margin.

'Habitat unknown.'

Fischer (1880) redescribed this same species in the large Iconograph of Kiener as Trochus rugosus, A. Adams:

"Trochus rugosus, A. Adams. *Testa anguste perforata, conoidea, crassa, rudis; anfractus 5-6, superne et plerumque erosi, oblique striati, sordide fusco-cinerei, fulvo obscure et radiatim flammulati, convexiusculi; ultimus tumidus, ad suturam late appressus, marginatus et irregulariter lamelloso-plicatus; spiraliter cingulatus, interdum radiatim subplicatus, infra convexus et concentrice, sulcis 6-7, apertura rhomboidea, nigro vel purpureo marginata; columella brevi, bidentata, dente superno majore; callo umbilicari perforationem partim tegente."*

This somewhat difficult description, in which important words seem to be missing, was accompanied by a more complete and comprehensive French description.

Fischer (l. c., p. 232) compares this species with "Trochus euryomphalus Jonas" which, he states, is 'equally perforate but differs by its coloration, its smaller shell, its spiral grooves etc.' (translation mine).

Pilsbry (1889) in Tryon's Manual describes the same species, again as Chlorostoma rugosum:

" Shell narrowly umbilicate, conoidal, solid, heavy, dull cinereous, more or less variegated by brown, blackish or red streaks; spire conoidal, generally eroded and white or yellow at the apex; whorls, about 5, obliquely striate, radiately coarsely and irregularly plicate and rugose above, sometimes nearly smooth; periphery rounded; base convex, concentrically lirate; aperture oblique; columella strongly dentate in the middle or below it, with a second small tooth at the base; edge of the columella rather deeply curved above the tooth, but spreading at its junction with the whorl, bounding and somewhat narrowing the umbilicus by a white callus, which does not extend to the upper margin of the aperture; umbilicus deep, white within. Alt. 26, diam. 27 mm. "

In the discussion of the species, following this more thorough description, Pilsbry adds: "A rude, rugose species, like C. aureotinctum; but much less coarsely sculptured, with narrower umbilicus . . . . "

Keen (1958, p. 259) states: "Tegula (Omphalius) rugosa (A. Adams, 1853) . . . . The rough turban shell is heavy and dull gray, variegated with brown, black, or red streaks; the whorls are roughly and irregularly sculptured with oblique folds and some spiral threads. The umbilicus is deep and white within. . . . "

In the collection of the Department of Zoology, University of California, Berkeley, there are eleven lots of Tegula rugosa from various collecting stations on the west shore of the Gulf of California. It was possible for me to collect two fairly large random samples of populations about thirty miles south of the town of San Felipe, Baja California, Mexico. These samples are from two different areas, perhaps less than 500 meters distant from each other, but separated by a sandy beach devoid of any rocks or other solid objects to which a Tegula might cling. The other lots in the collection of the Department have been received from various sources and do not represent truly randomly collected specimens, as none of these lots include juvenile specimens.

In comparing our specimens with the various descriptions, several discrepancies were noted. The umbilicus showed great variability, and similarly, the sculpturing of the shell did not agree closely with the descriptions. While it must be admitted that the definition of colors of a shell will always remain a more or less subjective undertaking, nevertheless, to my eyes the shells of Tegula rugosa appear green rather than gray or ashy. Because of these differences, rather striking to me, a careful examination was made of all 290 shells and the results were recorded. After the addition of two more lots early in 1962, the new total of 304 shells was again examined and the results were again recorded. It is sufficient to state that for two shell characters (umbilicus and ornamentation) the two sets of results were identical (except for the additional specimens); the appraisal of the color varied, but only very slightly.

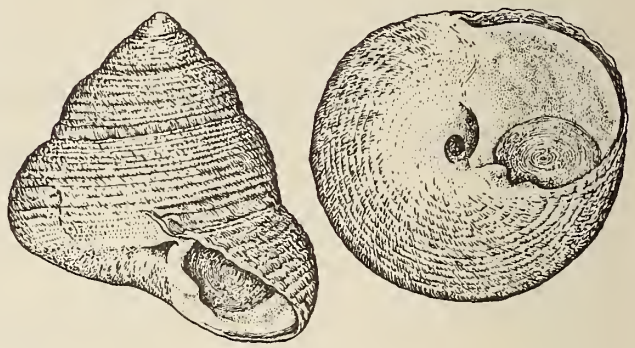


Figure 1: *Tegula (Omphalius) rugosa* (A. Adams, 1853) Lateral and ventral aspects of an unusually well preserved specimen. Puertecitos Cove, Baja California, Mexico. *ex coll.* Dr. Donald R. Shasky. x 1.6

Umbilicus: Figure 1 shows an exceptionally fine specimen of the species under discussion, from the collection of Dr. Donald R. Shasky; it is not included in our study but was used as it illustrates the various shell characters rather well. Among these, however, the umbilicus exhibits one of the extreme conditions observed — it is not only deep as stated in the original description by Adams (l. c.) but it is extremely wide open. Figure 2b illustrates the form of the umbilicus encountered in the majority of our shells (i. e. 50.33%); here the umbilicus is deep, indeed, but the columella forms what I call a 'fold', narrowing the umbilicus. Figure 2d represents perhaps a transition to the imperforate

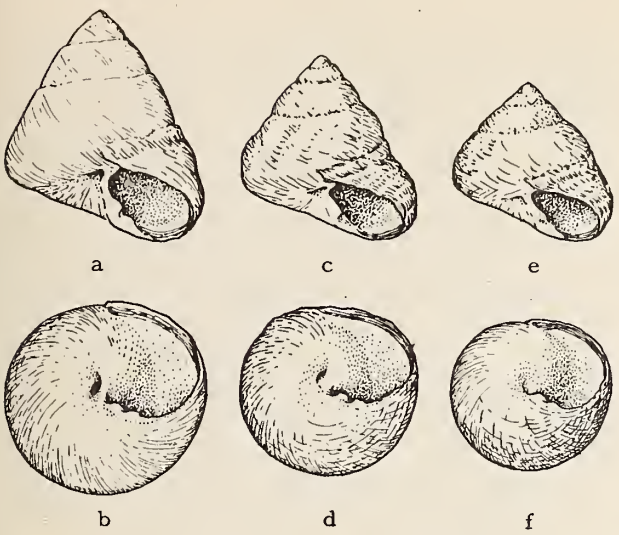


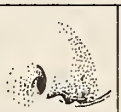
Figure 2: *Tegula* (*Omphalius*) *rugosa* (A. ADAMS, 1853)
Lateral and ventral aspects of specimens collected January 24, 1959, on rocks approximately 30 miles south of San Felipe, Baja California, Mexico.
Figure 2 a: unusually high form; figure 2 e: shape most commonly encounterd; figure 2 b: umbilicus narrowed by columellar callus; figure 2 d: umbilicus reduced to a "pit"; figure 2 f: umbilicus absent.
ex coll. Department of Zoology, University of California, Berkeley. x 1.0

condition, as here the callus formed by the columella narrows the umbilicus to what may be termed a mere pit, of variable depth, but never as deep as the two first mentioned conditions. Finally, the umbilical area may be closed, represented by a more or less shallow depression — or it may be completely flat and smooth.

In Table 1 are reproduced the results of my counts of the various lots, the latter arranged chronologically. Above the designations chosen for the various conditions of the umbilical area are small sketches showing the criteria used in segregating the individual specimens. It may be noted that 19.08 % are widely and deeply umbilicate, 50.33 % are narrowly and deeply umbilicate, 12.83 % are extremely narrowly and rather shallowly umbilicate, while a total of 17.76 % are imperforate; these latter shells may be separated into two groups (as stated above): one with a shallow depression, comprising 9.21 % of the grand total, the other completely imperforate, with 8.55 % of the grand total. Somewhat differently expressed, the shells in this study agree, as far as the perforation is concerned, only up to 70 % with the generally unanimous statement by the cited authors: "deeply umbilicate"; only slightly more than 62 % agree with Pilsbry's description: "narrowly umbilicate". If all the shells that show any sort of perforation are counted together, we find approximately 82 % in this category. In my opinion, however, the umbilicus which I designated as 'pit' does not agree with what the different authors described, and

Table 1

Frequencies in Differences in the Umbilical Area of *Tegula* (*Omphalius*) *rugosa* (A. ADAMS, 1853) in the Collection of the Department of Zoology, University of California, Berkeley

Locality	Date[2]	Collector	 wide open	 fold	 pit	 depression	 imperforate
San Felipe	II 1929	H. N. Lowe		2			1
Los Angeles Bay	23 X 1957	North & Scotten	1 (1)				
San Felipe	28 XI 1957	M. Turver	3 (3)	6 (1)	2 (1)	1	
30 mi S San Felipe[1]	24 I 1959	R. Stohler	31 (4)	128 (7)	20 (1)	13 (1)	8
60 mi S San Felipe[1]	I 1959	P. Fleischer	4				
30 mi S San Felipe[1]	20 II 1959	R. Stohler	9 (1)	5	11 (1)	10	15
N edge of San Felipe	21 II 1959	F. Wolfson				1	
36 mi S San Felipe[1]	22 II 1959	R. Stohler		1 (1)			
San Luis Gonzaga	27 III 1961	F. Wolfson	5 (1)	7 (4)	2	2	2
15 mi S San Felipe[1]	24 XII 1961	F. Wolfson		2	2		
Puertecitos	31 III 1962	F. Wolfson	5	2	2	1	
		Totals:	58 (10)	153 (13)	39 (3)	28 (1)	26

[1] approximate number of miles south of the town [2] months in roman numerals
The numbers in parentheses refer to individuals showing a wavy sculpture on the whorls

Table 2

Measurements (in millimeters) of the Largest and Smallest Specimens in a Random Population of *Tegula (Omphalius) rugosa* (A. Adams, 1853) from approximately 30 miles South of San Felipe

	Largest		Smallest	
	Height	Width	Height	Width
Umbilicus wide open	32.5	31.8	11.3	13.4
With fold	32.4	27.8	10.6	13.0
Pit	29.0	27.3	9.6	11.4
Depression	28.2	26.8	7.9	10.8
Imperforate	22.9	25.8	9.7	11.8

we would therefore have about 30% of the shells not covered by these descriptions.

It might be assumed that the condition of the umbilicus, i. e. whether it is wide open or completely imperforate, is correlated with the age of the animal. However, the figures in the accompanying Table 2 show clearly that this would be erroneous. In the sample of 200 specimens which I collected in January 1959 there were 28 measuring less than 20 millimeters in maximum height, and of these there were 7 measuring less than 14 millimeters. A shell of over 16 or 18 millimeters has the appearance of a "mature" shell, losing the juvenile character of being wider than high. This is not to say that among truly adult shells none will be found which are wider than high. Rather, all juvenile shells are much more obese, having an obesity index exceeding 100. As will be noted from Table 2, truly juvenile shells are represented in all five classes of umbilical condition, just as are adult shells.

Sculpture: Even more divergence is noted in regard to the character described by Pilsbry (l. c., p. 173, line 7) "radiately plicate and rugose above . . . ." This condition, illustrated in Figure 3, is observed in but 8.88% of our specimens (see Table 1, figures in parentheses). Particularly startling to me was the statement by Pilsbry (l. c.) in the discussion of Tegula rugosa: "A rude, rugose species, like C. aureotinctum; but much less coarsely sculptured, . ." It is true, the radiate plications on the whorls are similar to the regular sculpture of T. aureotincta (Forbes, 1852) but this, to my eyes, is the only similarity between the two species. It appears to me more similar to the variant in T. brunnea (Philippi, 1848) which Dall named twice, first in 1871 and then again in 1919: fluctuatum and fluctuosus, respectively. In a previous article of this general series of studies (Stohler, 1958) I showed that in T. brunnea the character under discussion varied from about 4% to about 28% in different populations. At that time I suggested that the sculpture of the exceptional specimens of T. brunnea indicated the possibility of parallel evolutionary trends and that the character may, or may not, eventually, occur in every individual of a population. My observations in T. rugosa seem to me to fit into the general thought expressed in that paper; the rather small percentage of individuals showing the trait seems to support the view that we are dealing with a mutation. It might be considered surprising that the exceptional character was noted in all the early descriptions and even in as recent a work as Keen's (l. c.) excellent book it is referred to as if it were the usual occurrence. To be sure, Pilsbry did state (l. c., p. 173, line 8): ". . . , sometimes nearly smooth; " Our samples would suggest rather the reverse description, i. e. "smooth, sometimes with oblique ribs. "

Shape: As noted above, the juvenile shells are much more obese than the adult shells. However, in a random sample of a population, such as the one mentioned before, comprising 200 specimens, a great variation in the shape of the adult shell will be noticeable. Figure 2, in addition to showing variation in the umbilical region, also illustrates some of the extremes encountered in the general shell shape. The relatively tall shell is comparatively rare in occurrence but is encountered frequently enough to be worth noting in a comprehensive description of the species.

Color: As already mentioned, color appraisal is subject to great variation due to the optical sense of the beholder as many subjective factors must enter into ascertaining of the color. Also already mentioned is the fact that the shells appear to me as green rather than as ash gray. However, comparing actual specimens with the colors in Maerz & Paul (1950) the following showed complete agreement:

Figure 3: *Tegula (Omphalius) rugosa* (A. Adams, 1853) Lateral and ventral aspects of a specimen collected January 24, 1959, on rocks approximately 30 miles south of San Felipe, Baja California, Mexico. This specimen shows the "coarse, oblique plications" (see text) *ex coll.* Department of Zoology, University of California, Berkeley. x 1.0

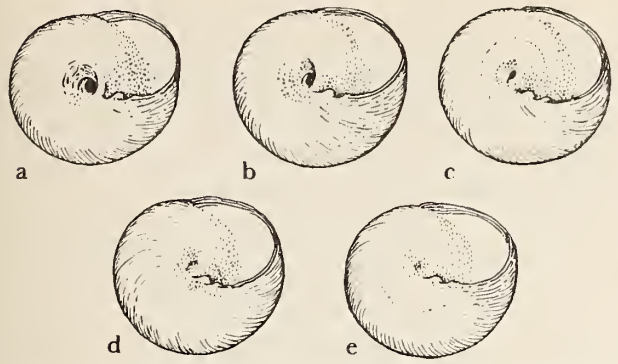


Figure 4: *Tegula (Omphalius) rugosa* (A. Adams, 1853)
Ventral aspects of five specimens collected January 24, 1959, on rocks approximately 30 miles south of San Felipe, Baja California, Mexico.
These shells show the various possible conditions of the umbilical area:
a: wide open; b: with fold;
c: pit; d: depression; e: imperforate.
ex coll. Department of Zoology, University of California, Berkeley. x 1.0

General shell color: Pearl Gray (M & P, plate 44, field 1 A) with green in the uneroded areas; the green varied, in different specimens, from M & P, pl. 22, field 1 I to pl. 22, field 6 L (which latter is called Peridot Green). The specks, rather than "lines" of some authors, appear to be pure black to purple (M & P, pl. 44, field 5 F). I failed to see any red markings anywhere. The lip of the aperture is bordered by a green band (M & P, pl. 22, field 7 A to pl. 22, field 5 A; the first of these is called American Green). The outermost edge of the lip, being thin, appears translucent with a yellowish tinge. I failed to encounter any truly brown (Adams, l. c.) or black to purple (Fischer, l. c.) color in my lots.

On the basis of the observations recorded above, the following amplified and emended description is offered:

Tegula (Omphalius) rugosa (A. Adams, 1853)

Shell top shaped, heavy, solid; umbilicus wanting to wide open and in the majority of specimens deep, white within; adult shell slightly to much higher than wide, usually eroded; dull green to pearl gray, flecked with black to purple spots; eroded areas may be white to yellowish; whorls rounded, variably sculptured with spiral threads; some specimens have faint to pronounced oblique folds; body whorl appressed at the suture to the penultimate whorl; aperture oblique, rounded; columella with two teeth in the upper half, the upper tooth much stronger and more prominent than the lower tooth; columella curved above the teeth, its callus in many cases spreading and narrowing the umbilicus; inside of aperture nacreous, bordered with a green to bluish-green band, about 1 to $1\frac{1}{2}$ mm wide, the extreme edge of the lip thin with a yellowish-green translucent color. The juvenile shell differs in that it is wider than high; body whorl is not appressed to the penultimate whorl; spiral threads distinct, usually a large one alternating with a small one; nepionic whorls usually eroded, white. The animal possesses four filamentous epipodial tentacles on each side of the foot, which is green in color; the color appears as criss-crossed short lines rather than a uniform patch of color; head and tentacles are also dark green.

Acknowledgment

I wish to express my appreciation to all those many individuals who have assisted this study in one way or another, be it through the gift or loan of specimens, be it through discussion and criticism. But a special word of thanks is due to Mrs. Emily Reid, Staff Artist, for the excellent illustrations reproduced here and those yet to be published.

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